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EXPERIMENTAL INVESTIGATION AND COMPARISON OF CI ENGINE PERFORMANCE WITH DIFFERENT PROPORTIONS OF FUEL ADDITIVES

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ABSTRACT

In recent years, an extensive research work has been carried on the performance testing of diesel engines with the fuel additives. The fuel additives are used to improve the combustion rate as they increase the surface area of fuel droplets to combustion. The fuel additives are largely associated with gasoline and oil-based fuels to reduce environmental pollution, improve mileage and power output of the engine. The use of additives helps to increase combustion rate, decreases harmful emissions, enable the use of fuels even at high temperatures. The present examination, an endeavor has been done to improve the performance of CI engine by blending additives in with diesel in various extents. The additives mixed with diesel in different proportions were designated as M1, M2 and M3 and the test results of these designated fuels are compared with pure diesel. The results show that the M3 fuel results in better engine performance by increasing brake thermal efficiency and decreasing brake specific fuel consumption (bsfc). A significant increase in brake power is also observed with M3 fuel at rated load conditions of the engine.

KEYWORDS: CI Engine, Combustion, Additive, Fuel Consumption & Brake Power

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Original Article

INTRODUCTION

Background Information

Diesel engines innovation has a significant contribution in the transportation area and over 90% of commercial vehicles are controlled by Diesel engines. The applications of the Diesel engines are vast and used in power river barges, marine work vessels, electric generators used as power backup in many places and finds its application in almost all commercial needs. The utilization of fuel added additives is one of the most significant advancements in the field of fluid designing. The fuel added additives are utilized to improve the fuel consuming rate, increase surface area and prevent corrosive effects. In the course of recent years, a huge assortment of fuel added substances have been utilized in light of a legitimate concern for ecological insurance by lessening discharges, to build mileage and force yield. An extensive work has been carried out to study the effect of adding ethanol-diesel blends with different types of additives on engine performance and exhaust emissions and the investigation is done through experimental modeling and optimization methods. The importance of biodiesel and its effective utilisation had been analysed by conducting experiments to find brake power, brake specific fuel consumption, emission characteristics (CO, NOx, HC etc.) and exit gas temperature. The authors concluded that the biodiesel with some additives (B20+1%) gives best performance and reduces the exhaust gas including NOx [1]. The consequences of execution and emission qualities of CI engine utilizing nanoparticles added substances in diesel, biodiesel and

water emulsified energizes had been accounted. The use of exhaust gas treatment devices i.e., catalytic converter, diesel particulate filter and their effect on the performance of CI engine were discussed. A review on use of fuel additives to reduce emissions and improve engine performance is being carried out. The authors found that the use of nanoparticle additives and water emulsified fuel is the best method of improving the performance and controlling the emissions. The review paper concluded that the use of nano fluid additives in diesel and biodiesel increases surface area to volume ratio, catalytic activity in nano size metal oxides and metals. The combustion is improved due to micro explosion phenomenon [2]

It has been seen that an improvement in the performance with the addition of 1,4-dioxane with the ideal mix of DWS (89.8%diesel+10%water+0.2%surfactant) [3]. The combustion and emission characteristics of diesel-MEA (2-methoxyetheyl acetate) blends were investigated. They recommended the use of blend containing 15% MEA by considering the engine power, fuel economy and emissions when the engine runs on the same parameters [4]. These researchers conducted experiments to evaluate the effect of anti-corrosion additives in biodiesel on diesel engine performance, smoke and wear characteristics. [5]

Bayindirli et. al investigated on ethanol-cerium oxide in diesel and enhancement of efficiency of the engine with reduction of exhaust emissions were observed [6]. Bayindirli et. al. conducted experiment on n-hexane and n-hexadecane to diesel at different volume concentrations and found the maximum heat energy release with minimizing exhaust emissions [7]. Keskin et. al. worked on metal and metal oxides of Mg as additives in diesel with improve in the basic property without significant impact on the engine performance [8]. Fayyazbakhsh et. al. was experimented on blended diesel ethanol (NE +MN) leads to decrease in emission of soot and also conducted blended diesel ethanol (MXEE+CE) got the best result compare to other additives [9]. Kaimal et. al. was tested with DEE additive blended with diesel results in reduction in BSFC and exhaust emissions [10].

Mahalingam, S et. al worked on rubber seed oil and aluminum oxides were blended with diesel, and efficiency and combustion character improvement has been observed [11]. Attia et. al conducted experiment on nano additive with diesel and commented that the exhaust emissions were reduced drastically with 6% reduction of BSFC [12]. A review was done on blending of oxygenated additives at different percentages with sole diesel and studied the effects on various performance parameters. [13]. They investigated, FMAX diesel additive and HDOS lubricant oil additive and the effect of catalyst and polar additives on engine performance and exhaust emission.. The researchers recommended the use of FMAX with fuel in the proportion of 1:4000 to achieve higher power output [14].

EXPERIMENTAL SETUP AND PROCEDURE

The setup comprises of a Computerized Four Stroke Single Cylinder Diesel Engine with electrical dynamometer. Figure 1 shows the block diagram of the experimental test rig used for conduction of experiment, Figure 2 & 3 shows the Engine that is used for conduction of experiment and preparation of mixture by adding fuel additives with diesel in different proportions. Specifications of the engine are listed in Table 1. The Engine Instrumentation panel consists of air rate indicator to show air flow rate, torque indicator to measure the torque load applied to the engine, speed indicator to measure rpm of the engine, fuel rate indicator to indicate the quantity of fuel consumed by the engine, temperature indicators to measure temperature, exhaust gas calorimeter and combustion pressure sensor with water cooling.

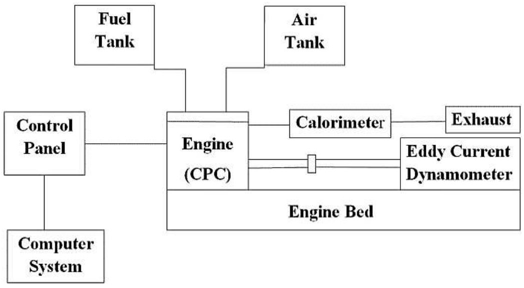

Figure 1: Experimental Set-up.

Figure 2: Computerised Four Stroke Single Cylinder Diesel Engine Test Rig.

The aim of the research work is to investigate the performance of Computerised Four Stroke Diesel Engine with different proportions of fuel additives mixed with diesel and compare the results with performance of diesel engine with pure diesel fuel without any additives. Table 2 shows the proportions of the mixture i.e., diesel and fuel additives in different proportions. The experiments are conducted by changing the torque and the load changes are recorded in terms of percentage. For different load percentages, the output variables such as engine speed, fuel flow rate, water flow rate to the engine and calorimeter are measured and the corresponding combustion curves are obtained.

Figure 3: The Mixture of Diesel and Fuel Additives Mixed in Different Proportions

Table 1: Mixture Compositions of Test Fuels

Fuel	Proportion of Additive
Diesel	Nil
Mixture 1 - (M1)	5 liters of Diesel + 1.0 ml of fuel additive
Mixture 2 - (M2)	5 liters of Diesel + 1.5 ml of fuel additive
Mixture 3 - (M3)	5 liters of Diesel + 2.0 ml of fuel additive

Table 2: Specification of Test Engine

Engine & its Parameters	Specification
Engine	4 stroke Single cylinder water cooled VCR diesel engine
Make	Tech-Ed
Rated Power	Up to 5HP
Bore Diameter	80mm
Stroke length	110mm
Connecting rod length	234mm
Swept volume	552cc
Compression ratio	12:1 to 20:1
Rated speed	1500
Rated toque	24 N-M
Dynamometer	Electrical

The Flash and Fire point of the diesel and additives mixed with Diesel in different proportions were determined experimentally by using Penskey- Martens apparatus and were tabulated as shown in Table 3. It was observed that the Flash and Fire point decreases with increase in proportions of fuel additives in diesel (from M1 to M3). The decrease in these properties may be due to improper chemical bonding between diesel and additive molecules.

Table 3: Flash and Fire Point of Diesel and Additive Mixtures

Fuel	Proportion of Additive
Diesel	Nil
Mixture 1 - (M1)	5 liters of Diesel + 1.0 ml of fuel additive
Mixture 2 - (M2)	5 liters of Diesel + 1.5 ml of fuel additive
Mixture 3 - (M3)	5 liters of Diesel + 2.0 ml of fuel additive

RESULTS AND DISCUSSIONS

The impact of fuel additives in various extents blended with diesel is examined at different loads by considering the variation of pressure with crank angle. The engine performance can be evaluated by considering the impact of load. An optimal mixture of fuel additive and diesel can be obtained for best engine performance.

Pressure and Crank angle

The variation of cylinder peak pressure with crank angle at the end of compression and throughout the expansion stroke is obtained for diesel and for different proportions of fuel additives with diesel i.e., M1, M2 and M3. The combustion rate will influence the trends of the peak pressure obtained in the cylinder with respect to crank angle and a maximum of 73bar peak pressure is obtained with fuel mixture M3. A peak pressure of 68 bar is observed with diesel fuel and its value increases to 70 bar, 71 bar and 73 bar with fuel mixture M1, M2 and M3 respectively. The high peak pressure with M3 fuel is due to low viscosity and proper atomization of mixture particles that results in high heat release rate and improved thermal efficiency. The combustion process accelerates with increase in proportions of fuel additives and is high with M3 mixture and resulted in high peak pressure. Similar trends were observed for different loadings on the engine.

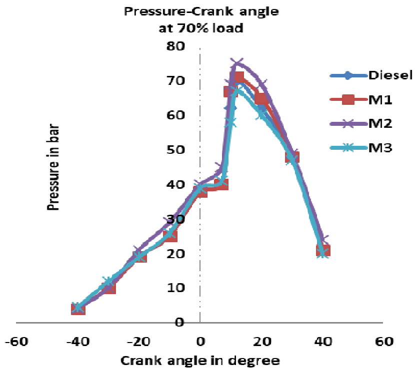

Figure 4: Variation of Pressure with Crank angle for Different Fuel Blends at 60% Engine Loading

Effect of Load on Brake Thermal Efficiency with Different Proportions of Fuel Additives in Diesel

The influence of load on Brake thermal efficiency for different mixture of additives with diesel and pure diesel is shown in Figure 5. It is examined that the thermal efficiency enhanced by 3 to 6% with M1 fuel at all the running conditions of the engine and increases up to 8% with M3 fuel. A reduction in brake thermal efficiency has been obtained with M2 fuel at part loads. At 70% load, the brake thermal efficiency is 17.75% with diesel operation and increases to 18.67% with use of M1 fuel. The brake thermal efficiency decreases to 17.82% and 18% for M2 and M3 fuels respectively. It is also examined that the brake thermal efficiency improves with increase in load for all fuels. The use of M1 fuel gives higher brake thermal efficiency than other fuel mixtures when the engine is running with 20% load. The brake thermal efficiency for all blended fuels improved about 2-6% at all the loads. It indicates that the brake thermal efficiency can be improved by adding additives to the diesel and the use of M3 fuel gives better results compared to other fuels. The use of additives in diesel decreases the boiling point of mixture lower than pure diesel and this results in improved evaporation properties of the fuel and accelerates the combustion and increases brake thermal efficiency. The M3 fuel contains more cerium oxide constituent compated to other fuels and this results in liberation of more oxygen and acceleration of combustion, resulting in higher thermal efficiency at different loading conditions of the engine.

Table 4: Effect of Additive Mixture on Brake Thermal Efficiency

Type of Additive Mixing with Diesel	Brake Thermal Efficiency	Remarks
M1	Increases by 1-6% for different loads	Desirable
M2	Decreases at part loads	Adverse effect at part loads
M3	Increases by 1 to 8% for different loads	Significant

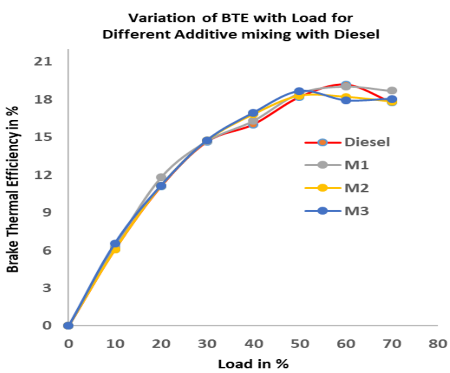

Figure 5: Brake Thermal Efficiency with Load

Effect of Load on Brake Specific Fuel Consumption with Different Proportions of Fuel Additives in Diesel

Figure 6 shows the variation of brake specific fuel consumption (bsfc) with load for all proportions of the mixtures. It was observed that the mixture M3 gives lower bsfc for all the loads and the least value of 0.42kg/kWh was achieved at 60% loading. The mixing of 2.5ml fuel additive per 5 litre diesel (M3 fuel mixture) gives maximum thermal efficiency (with a percentage increase up to 7%) and lowest bsfc (decreases up to 7%). The percentage decrease in bsfc is high at part load and slightly low at higher loads. The bsfc decreases with increase in engine load. For pure diesel, bsfc is higher compared to other fuel mixtures and its value ranges from 1.30kg/kWh at 10% loading to 0.445kg/kWh at 70% loading. The addition of additive particles to diesel decreases bsfc for all ranges of load and M3 mixture gave better results especially at full load conditions. The bsfc decreases with M3 mixture composition may be due to improved combustion caused by better evaporation and spray characteristics of the mixture

Table 5: Effect of Additive Mixture on BSFC

Type of Additive Mixing with Diesel	BSFC	Remarks
M1	Decreases by 1-6% for different loadings	Desirable
M2	Decreases by 1-5% for different loadings	Adverse effect at part loads
M3	Decreases by 1-7% for different loadings	Significant

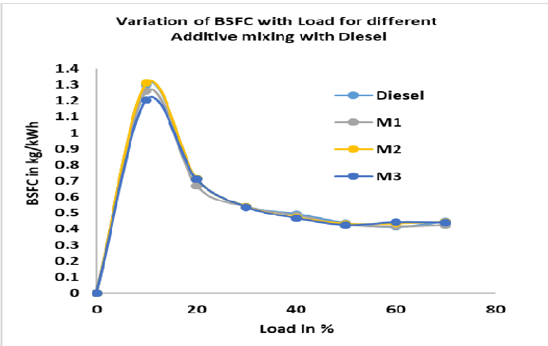

Figure 6: Variation of BSFC with Load

Effect of Load on Break Power with Different Proportions of Fuel Additives in Diesel

Figure 7 shows the variation of Brake Power with Load for different mixture composition of additives with diesel. The Brake Power output increases from 0.39kW to 2.6kW at part load and full load respectively during operation with pure diesel. The power output decreases with addition of fuel additives in small proportions (M1 and M2) to diesel and increases by 1% when proportion of additive added to diesel increases to 2ml/5 liters of diesel (M3 mixture). This implies that the addition of 2ml fuel additive is more effective than other proportions and exhibit better performance due to good combustion quality and more reliable fuel viscosity

Table 6: Effect of Mixture on Break Power

Type of Additive Mixing with Diesel	Brake Power	Remarks
M1	Decreases by 0.2 to 0.6% for different loadings	Less effect
M2	Decreases by 0.2 to 0.5% for different loadings	Less effect
M3	Increases by 0.2 to 1% for different loadings	Significant

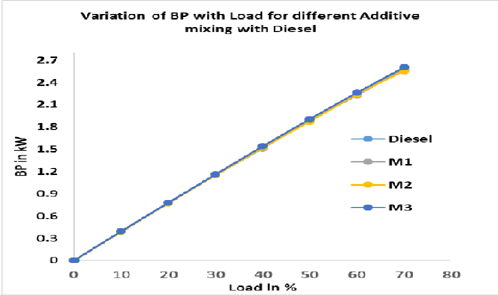

Figure 7: BP with Load

CONCLUSIONS

The performance of the Computerised Four Stroke Single Cylinder CI Engine is evaluated with pure diesel and different proportions of fuel additives and the results are summarized as follows.

- The flash and fire points of pure diesel and mixture M1, M2 and M3 were obtained and the results indicate that both flash and fire points decrease with addition of fuel additives and a lower value of 36°C and 45.8°C were recorded for M3 fuel mixture.
- The maximum pressure rise for diesel and mixtures are calculated and for M3, the highest peak pressure of 73 bar at 1500rpm at 60% load is noted.
- At 60% load condition, the break thermal efficiency for M3 is increased by 3.33% as compared to diesel and where as M1 and M2 are increased by 2.03 and 2.45% respectively.
- At 60% load condition, the BSFC for M3 and diesel is obtained almost the same value but for M3 the heat released is more compared to diesel.
- The engine power output increases by 1% for M3 fuel when compared to pure diesel.

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